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Biomass briquetting and its perspectives in Brazil

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ABSTRACT

A study of the status of biomass briquetting and its perspectives in Brazil was conducted including determination of the availability and characteristics of the agro-residues for briquetting. Wood residues, rice husk and coffee husk were characterized and identified as the more promising agro-residues for briquetting in the short-term in Brazil. A survey was carried out in order to determine the number of briquetting factories in Brazil, and also to determine: used briquetting technologies, briquettes production, briquettes sale prices, the status of biomass briquetting market and its future perspectives.

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1. Introduction

In Brazil, since the mid 1970s several governments have implemented energy policies to increase the use of biofuels. The Brazilian Fuel Ethanol Program (ProAlcool) was a successful example to stimulate the use of ethanol as automotive fuel, and nowadays it attracts the attention of the world [1]. Another example of these policies is the recent National Program of Production and Use of Biodiesel (PNPB), which intends to substitute 2% of diesel in omnibus and trucks [2]. However, the use of biomass residues as energy source has not had the same success, partly for the lack of an adequate program and also because of the inherent difficulties in the use of these residues.

Brazil is eminently an agricultural country. Each year about 330 millions of metrics ton (Mg) of biomass residues are generated in the country. These residues frequently are not used as energy source, because they have poor energy

characteristics (low density, low heating value, and high moisture content), causing high costs during transportation, handling, and storage. Some of these drawbacks could be overcome if biomass residues were densified into briquettes, in order to provide more energy per unit of volume, to improve transportation and storage [3,4]. Biomass briquettes are not widely produced in Brazil yet. The expansion of this sector depends basically on three factors: residue availability for briquetting, adequate technologies and the market for briquettes.

2. Residues availability and their characteristics in Brazil

The amount of biomass residues can be estimated by the agricultural production and the respective residues coefficient

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Table 1 – Estimates of the main biomass residues generated in Brazil.

Crop	Year 2006 Production ($10^6 \times \text{Mg}$)	Residues	Residue coefficient	Residue amount ($10^6 \times \text{Mg}$)
Rice	11.5	Rice Husk ^b	0.18	2.0
		Paddy Straw ^a	1.43	16.4
Coffee	2.5	Coffee Husk ^b	0.21	0.54
Sugar Cane	457.2	Bagasse ^d	0.28	123.4
Bean	3.4	Bean Straw ^a	2.10	7.2
Maize	42.6	Maize Straw ^a	1.00	42.6
Soya	52.4	Soybean Husk ^b	0.01	0.52
		Soya Straw ^a	2.10	110.1
Wheat	2.4	Wheat Straw ^a	1.30	3.2
Logwood ^c	100.7	Wood Residues ^b	0.30	30.2

a crop wastes.

b agro-industrial residues.

c Year 2006 Production in m^3 .

d Bagasse residue coefficient from [18].

[5–7]. An estimate of main biomass residues generated in Brazil, taking into account the annual production of these crops in 2006 [8] is shown in Table 1.

The residues showed in the Table 1 can be divided in two types of residues: crop wastes and agro-industrial residues. The crop wastes include the residues which remain in the field after harvesting, for instance, paddy straw, bean straw, soya straw, maize straw and wheat straw. These residues add about 180 millions metric ton per year (Mg yr^{-1}). Only, a small fraction of this amount would be practically recoverable even under conditions of highly mechanized harvesting, which are not widely implemented in Brazil yet. On the other hand, the crop wastes have other important uses such as animal feed and bedding, as well as soil fertility factor. Currently, the crop wastes are practically unused as feedstock for briquetting in Brazil and it seems to be that this situation will not change radically in the near future.

The agro-industrial residues include rice husk, coffee husk, bagasse, soybean husk and sawdust, which are generated during the processing of the crops or logwood.

Virtually all of these residues could be used for briquetting, because they are homogeneous, contain below 15% moisture and are concentrated on the plants.

The sugar cane bagasse is the most abundant of these residues (Table 1). As rule, almost all generated bagasse is used in order to meet energy demand of sugar and ethanol manufacturing process. Moreover, the sugar cane bagasse has high moisture content (about 50%) and so much energy is necessary for its drying before its briquetting. These factors suggest that the sugar cane bagasse is less appropriate for briquetting than other residues such as rice husk, coffee husk and sawdust, which have homogeneous particle size, very good flowability and moisture content below 15%.

2.1. The studied cases

The wood residues (sawdust, wood chipping, shavings, and offcuts), rice husk, and coffee husk are the residues with highest feasibility for briquetting in the short-term in Brazil. Case study for determining the availability of these residues and its geographic distribution in Sao Paulo State was conducted.

2.1.1. Wood residues

A database of the enterprises in the State of Sao Paulo was used for determining the number of enterprises which generate wood residues and rice husk [9]. About 297 enterprises were found, of which 274 are sawmill or furniture industries and the another 23 are rice-mill. In order to know the amount of residues generated by these enterprises most managers were interviewed.

In the Table 2 is shown the geographic distribution of wood residues by micro-regions and the amount of enterprises in the Sao Paulo State. Most of enterprises found were micro and small-size (Table 2). Both categories generate about 80 Mg yr^{-1} . The medium and large size enterprises generate 375 Mg yr^{-1} , and $60,000 \text{ Mg yr}^{-1}$ respectively. The medium size and large size enterprises represent 11% of the enterprises found in the State of Sao Paulo.

The medium, small, and micro enterprises declared to sell all residues at a price in the range from 60 to $100 \text{ R\$ Mg}^{-1}$ (in

Table 2 – Wood residues distribution by regions and amount of enterprises in São Paulo.

Microregion	Company size			Residues (Mg yr^{-1}) ^a
	Micro and small	Medium	Large	
Central Region	5	1	0	780
Araçatuba	4	0	0	324
Bauru	20	1	0	1995
Campinas	51	5	0	6006
Franca	2	0	0	162
Marília	11	0	0	891
Presidente Prudente	3	0	0	243
Ribeirão Preto	3	0	0	243
Santos	2	0	0	162
São José do Rio Preto	6	0	0	486
São José dos Campos	9	2	0	1479
Sorocaba	52	11	2	128337
São Paulo Metro Area	78	6	0	8568
TOTAL	246	26	2	149676

a Average values.

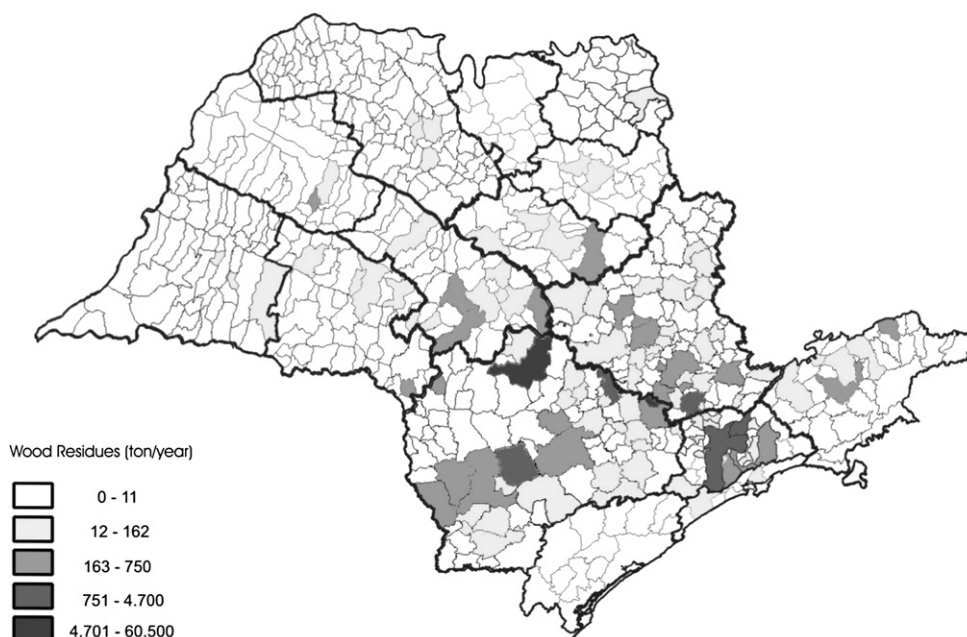


Fig. 1 – Geographic distribution of wood residues by microregion in the Sao Paulo State.

February 2008 the exchange rate was 1 USD\$ = R\$ 1.70), when were being charged by buyer. On the other hand the large enterprises declared to use all residues internally for energy generation. It was estimated that around 30,000 Mg of these residues are available for briquetting each year. Most of these residues are sawdust.

In the Fig. 1 is shown the geographic distribution of wood residues by regions in the State of Sao Paulo. Most of these residues are generated in the micro and small enterprises which are 89% of the enterprises (Fig. 1).

2.1.2. Rice husk

Almost all of the 23 rice-mills were small enterprises. Each of these enterprises generate between 720 and 2400 Mg yr⁻¹ of rice husk with selling prices in the range from 30 to 60 R\$ Mg⁻¹. Only a small part of these residues is used as fuel. The owners are looking for alternatives for increasing the use of rice husk as an energy source and consequently increasing their revenue in the trade. In the Table 3 and in Fig. 2 is shown the distribution of rice husk generated in Sao Paulo State. Unlike wood residues there is a great concentration of rice husk due to the limited number of rice-mills in the state. According to data base of the Brazilian Institute of Geography and Statistics (IBGE) the Sao Paulo State produces annually around 82,800 Mg of rice, generating around 14,900 Mg of rice husk [8]. However, during this field research an amount about 45,000 Mg of rice husk was identified. This divergence is probably due to the great amount of processed paddy brought from other Brazilian States to the State of Sao Paulo.

2.1.3. Coffee husk

About 95% of the coffee grain is processed by dry way, resulting in residues formed by epicarp and endocarp [10]. The coffee grain processing is carried out in farms or in cooperatives of small producers. Due to lack of trustworthy data, it has not been possible to carry out a detailed survey of the coffee mills

on Sao Paulo State. Although there are not trustworthy data on geographical distribution of coffee husk residues, it is right to suppose that most of coffee husk residues should be concentrated in the regions of coffee plantations which are located in the north border of the Sao Paulo State with Minas Gerais State. A small part of these residues is used as fuel in order to dry the coffee grains and another part is sold for animal bedding or used in the plantations as soil fertilizer. In spite of the existence of several ways for coffee husk disposal, currently, a large excess of coffee husk still remains after finishing the harvest in the farms. This situation provokes serious environmental concerns among the farm owners, which are looking for alternatives to use efficiently these residues.

According to IBGE [8] the Sao Paulo State annual production is around 260,000 Mg of coffee, generating around 54,500 Mg of coffee husk.

Table 3 – Rice husk distribution by region and number of enterprises in São Paulo.

Region	Company size		Residues (Mg yr ⁻¹) ^a
	Micro	Small	
Central	0	2	4320
Bauru	0	1	2160
Campinas	0	2	4320
Marília	1	7	15840
Presidente Prudente	0	3	6480
Ribeirão Preto	0	1	2160
São José do Rio Preto	0	1	2160
Sorocaba	2	1	3600
São Paulo Metro Area	0	2	4320
TOTAL	3	20	45360

a Average values.

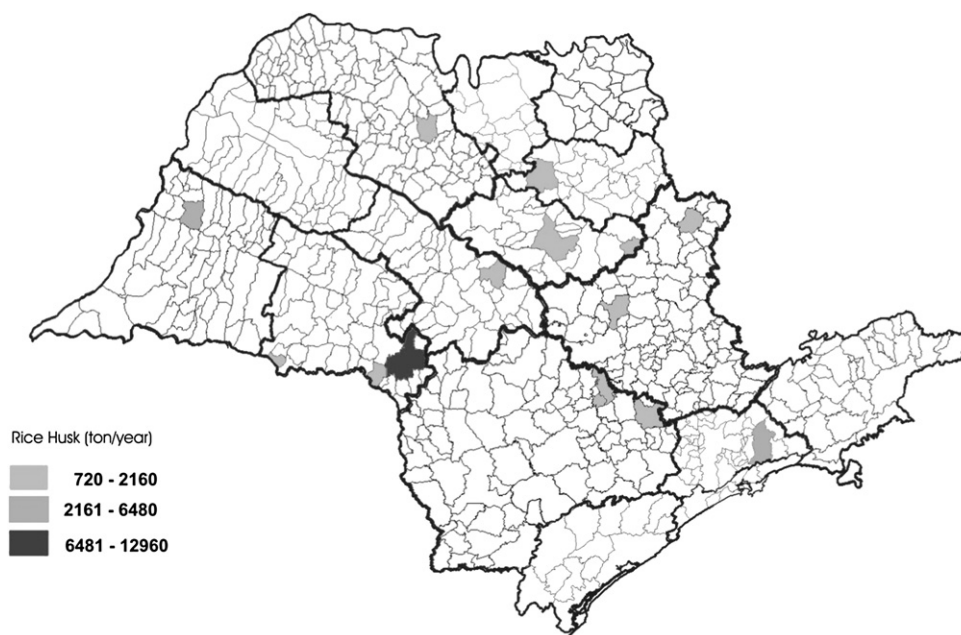


Fig. 2 – Geographic distribution of rice husk by micro-regions in the State of Sao Paulo.

2.2. Thermochemical proprieties and particle size distribution of residues

Samples of sawdust, rice husk, and coffee husk were collected and analyzed to determine their thermochemical properties [11–13] and particle size distribution [14].

Sawdust presents the lower moisture and the lower ash content when compared to other residues. It also presented an uniform particle size distribution becoming an excellent feedstock for briquetting (Table 4) (Fig. 3). Coffee husk presents good thermochemical properties, low moisture, good flowability, and its heating value is very similar to sawdust.

Rice husk is an exceptional residue; it has good flowability, and low moisture content (11.4%) (Fig. 3). Although rice husk presents higher ash content (17.0%) than other residues, these ashes contain fewer alkaline minerals; thereby rice husk ashes have a high ash sintering temperature. Biomass residues usually have lower ash content, but their ashes have higher potassium content, which have a tendency to devolatilise during combustion and condense on superheated surfaces. Therefore, biomass with lower ash

content does not mean that it will not show any slugging behavior during combustion [15].

3. Status of biomass briquetting in Brazil

A search to localize the briquetting plants spread out in the country was carried out considering the following aspects:

- Type of briquetting technology,
- Installed capacity,
- Feedstock,
- Briquette production,
- Briquettes market and its extension,
- Sale price.

3.1. Briquetting enterprises and their technology

Fifteen enterprises distributed in seven Brazilian States were found (Fig. 4). All briquetting machines installed in these factories are piston presses type, which almost are all

Table 4 – Thermochemical properties for residues.

Residue	Thermochemical Properties								
	Moisture (%)	Proximate analysis (%)			Ultimate analysis (%)				Heating Value (MJ/kg)
		VM	FC	Ash	C	H	O	N	
Sawdust	9.1	81.8	18.0	0.2	48.3	6.1	45.3	0.2	18.0
Rice Husk	11.4	65.9	17.1	17.0	35.5	5.2	42.1	0.2	14.0
Coffee Husk	13.1	73.2	23.1	3.7	47.5	6.4	43.7	—	18.4
VM-Volatile matter. FC-Fixed carbon.									

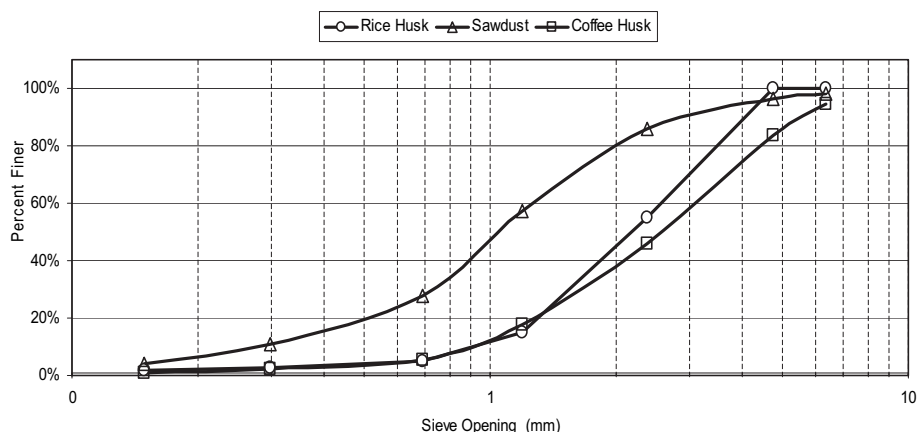


Fig. 3 – Residues sieving analysis.

mechanical piston press and only two are hydraulic piston press type. Most of all installed briquetting machines are manufactured by Biomax (Brazilian producer). Only one machine manufactured by other domestic company was identified. Others two enterprises had imported their machines.

Most of the enterprises were created specifically to produce and to commercialize briquettes from residues supplied by external farms. In few cases the briquetting operation consists of the installation of briquetting machines on a furniture factory or in a sawmill. In both cases the briquetting is used in

order to solve a waste-disposal problem and to make some additional revenue.

3.2. Briquette production

Most of the enterprises use wood residues as feedstock. Only two enterprises that use different feedstock were found. One factory located in Mato Grosso State uses rice husk and another located in Sao Paulo State uses wood waste from pencil production.

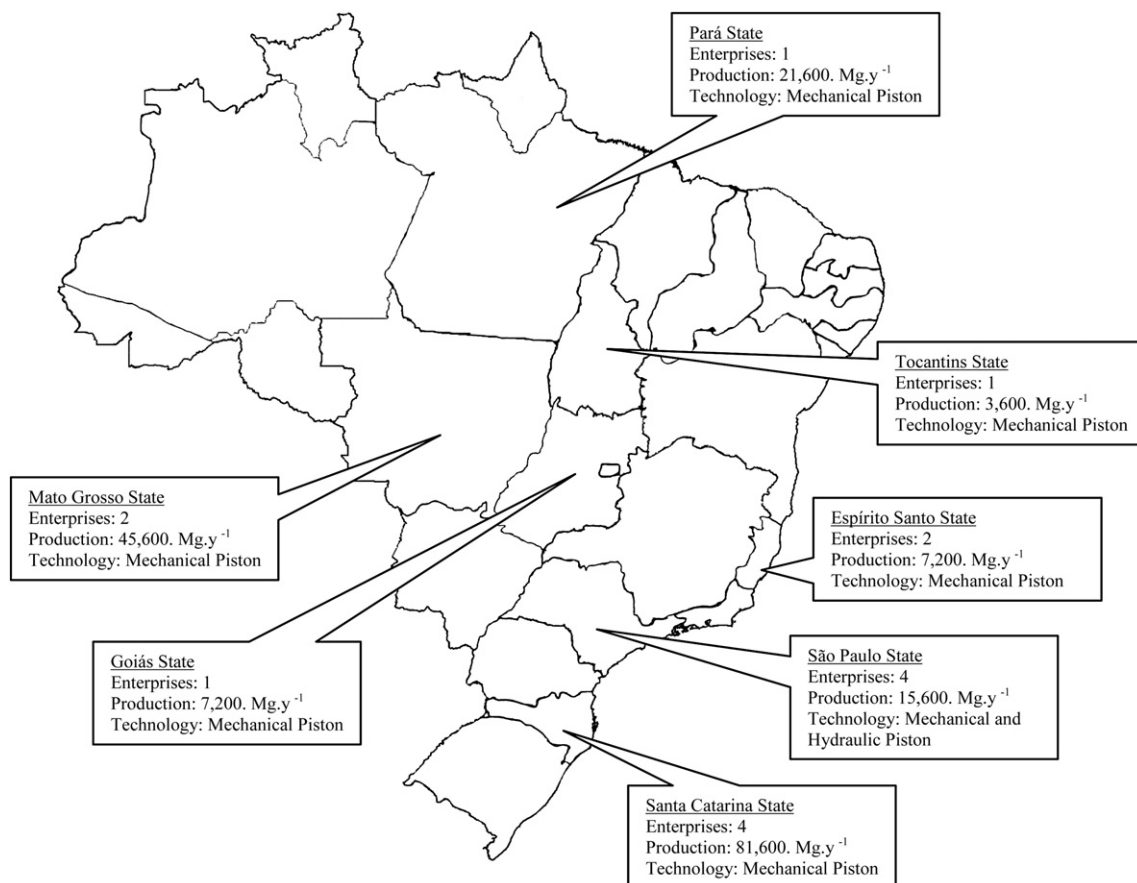


Fig. 4 – Geographic distribution of briquetting plants in Brazil.

Biomax to have also sold briquetting machines for companies that process other residues, such as sugar cane bagasse, coffee husk, and cotton shell. However, these companies had not been found in the official database.

The briquette production for almost all enterprises was not always proportional to their installed capacity and lazy production capacities were detected. The smallest briquettes production belonged to an enterprise located in Sao Paulo State. This enterprise produces about 2400 Mg yr⁻¹, in spite of having an installed capacity of 10,320 Mg yr⁻¹. The largest briquettes production belonged to an enterprise located in the State of Santa Catarina which produces about 60,000 Mg yr⁻¹. In this case the full installed capacity (7 Mg h⁻¹) is used. Most of enterprises produce between 3600 and 8400 Mg yr⁻¹. Only four enterprises produce more than 12,000 Mg yr⁻¹. The overall production of all enterprises found in this study was about 180,000 MG yr⁻¹. This production figure should be considered carefully because it is probable that there are small briquetting plants without any kind of registration as a homemade production.

3.3. The briquettes market

About half of the briquetting manufacturers declared to focus their sales in a regional market. Among them, for example, one factory informed that they sell its production in the region until a distance limit of 300 km because beyond that distance the sales are economically impracticable. Another half of the producers declared to sell their briquettes production countrywide. Moreover, four enterprises of this group export their production to the United States and Europe. The market extension is not related to the amount of briquettes production, for example, there is a big enterprise that sells 42,000 Mg yr⁻¹ in a regional market, while some small producers have reached the foreign markets.

The markets for briquettes are food stores, pizza restaurants, bakeries, and also factories with fuelwood-burning furnaces, like red brick factories. There are a large number of these stores (more than 12,000) predominantly in Sao Paulo, Minas Gerais and Santa Catarina States [16].

The briquette sale prices vary in a large range depending on customer type, the size of purchase order, and eventually from delivery distance, when the delivery service is offered by the briquette manufacturer. In general, prices are in the range from 200 to 305 R\$ Mg⁻¹ in the local market, with an average price of 250 R\$ Mg⁻¹. Only one of researched enterprises declared a sale price of 300 US\$ Mg⁻¹(FOB).

Some briquetting enterprises had installed systems to sell via website directed to small customers. In this case, the briquettes are delivered in bags, with gross weight between 25 and 40 kg, and selling prices from 450 to 560 R\$ MG⁻¹, including the freight. Producers' websites usually display the sign "ecological firewood" as a market tool.

4. Conclusions

These studied cases allow concluding that: wood wastes, rice husk, and coffee husk are the more promising agro-residues to briquetting in a short-term in Brazil. These residues are

about 32×10^6 Mg yr⁻¹. Currently, only a small part of these residues is briquetted. In the State of Sao Paulo, for example, annually are generated 129,000 Mg, of which only 12% is briquetted (15,600 Mg).

Many factors contribute to this scenario, among them is the geographic dispersion. Most of these residues are generated in small or micro enterprises which have residue production less than of 0.5 Mg ha⁻¹. During the search 274 sawmill and furniture enterprises were found in São Paulo State of which around 90% were micro-size and small-size enterprises.

The only one available technology in the national market is the mechanical piston press which commonly has capacity above of 0.5 Mg h⁻¹. For this reason it is usual to find an over dimensioning of installed capacity in several briquetting enterprises.

This situation has limited the briquetting activities to a few regions with high wood residues concentration. In these regions could be feasible setting up larger briquette factories which could use (in addition to the waste produced in the region) the residues supplied by external farms located in other regions where the amount of generated residues is not large enough to guarantee a production economically feasible.

The installations of briquetting machines on rice-mills, furniture, and coffee farms are unusual due to the lack of appropriate technologies. The use of mechanical piston presses in these small-size enterprises is unfeasible, because these machines could become underutilized and they are very expensive. For these cases screw press briquetting machines technology is a better option.

Regarding the small size of producer enterprises the implementation of briquetting presses machine with small capacity would be an alternative to increasing biomass briquetting in Brazil. These presses are typically designed with a capacity between 50 and 500 Kg h⁻¹, consequently they are very suitable for using in enterprises with small residue generation (less than 500 Kg h⁻¹). The briquettes produced using screw presses briquetting machines, unlike piston press briquettes, are suitable for carbonization, gasification, and torrefaction. Therefore screw press briquettes could be more attractive and could open up new commercial possibilities for briquettes in Brazil [17].

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